

(a) calcining a raw material containing a lithium compound under an oxidizing atmosphere to form calcined powders;

(b) mixing the calcined powders organic fibers and/or organic polymer particles to form a raw mixture;

(c) forming the raw mixture into a raw electrode; and

(d) heating the raw electrode to remove any organic fibers and any organic polymer particles.

IN THE SPECIFICATION:

Please add the following paragraph before the paragraph beginning on page 1, line 3:

--This application is a divisional of copending Application No. 09/125,452, filed August 19, 1998, now U.S. Patent 6,287,728 B1, the entire contents of which are hereby incorporated by reference and for which priority is claimed under 35 U.S.C. § 120. Application No. 09/125,425 is the national phase under 35 U.S.C. §371 of prior PCT International Application No. PCT/JP97/04709 filed on December 19, 1997, which designated the United States of America, and claimed foreign priority of Application No. 8-343166 filed in Japan on December 24, 1996.--

Please replace the paragraph beginning on page 4, line 16 to page 5, line 8, with the following rewritten paragraph:

-- It is preferred that this plate-shaped porous sintered material contains pores of an average diameter of 0.01 to 100 μm , preferably from 0.1 to 50 μm , and particularly from 0.1 to 10 μm , in the proportion of 15 to 60%, and normally from 25 to 50%, based on the total volume. Because the proportion of the pores must be not more than 60% in a volume proportion in order to increase the amount of the electrode material in the electrode in comparison with the case where the electrode is formed by using a conventional powder material. Since the electrolyte solution must be penetrated into the electrode, the proportion of the pores is preferably not less than 15%. When the diameter of the pores is not more than 0.01 μm , the electrolyte solution does not easily penetrate and it is not suitable for practical use. Since ions flow in the electrolyte solution in the form of solvation, the diameter is preferably large such that the resistance does not become too large even if the current density becomes comparatively large. The maximum diameter must be not more than 100 μm so as to protect the entire structure by this wall thickness and the proportion of the holes is adjusted to not more than 60% based on the whole volume. The term "porosity (proportion of the pores)" used herein means an open porosity and was measured by the Archimedes' method. The average diameter was measured by the mercury penetration method. --

Please replace the paragraph beginning on page 7, line 2 to page 8, line 28, with the following rewritten paragraph:

--By the same reason, the above negative electrode 3 is composed of a porous sintered material which is plate-shaped and has a thickness of 100 μm to 2 mm, and the porous sintered material contains pores of an average diameter of 0.1 to 100 μm , preferably from 0.1 to 50 μm , and particularly from 0.1 to 10 μm , in the proportion of 15 to 60%, and preferably from 25 to 50%, based on the total volume, and an average wall thickness between the pores is not more than 40 μm . Examples of the material for negative electrode used in the present invention include publicly known electrode materials such as carbon material, oxide of Groups IIIb-Vb, metallic aluminum, silicon, silicon compound and the like. As the carbon material, there can be used carbon material such as natural graphite, coke, glassy carbon graphite precursor or the like. Particularly, a carbon material obtained by calcining a raw material, which is carbonized by a heat treatment, is preferred. The material, which is carbonized by a heat treatment, is not specifically limited, and specific examples thereof include thermosetting resins such as phenol resin, epoxy resin, unsaturated polyester resin, furan resin, urea resin, melamine resin, alkyd resin, xylene resin or the like; condensed polycyclic hydrocarbon

compound such as naphthalene, acenaphthylene, phenanthrene, anthracene, triphenylene, pyrene, chrysene, naphthacene, picene, perylene, pentaphene, pentacene or the like, or a derivative thereof; or a pitch containing a mixture of them as a main component. Particularly preferred aspect is a plate-shaped negative electrode material comprising substantially 30 to 90% by weight of silicon and 10 to 70% by weight of carbon, which is obtained by mixing silicon or a compound thereof with a carbon material or a carbonized material obtained by calcination of the carbon material, and calcining the mixture under a non-oxidizing atmosphere at 600 to 1500°C. When organic fibers (those having a diameter of about 0.1 to 100 µm) of wool, cotton, silk, nylon, acrylic, acetate, polyester and the like or organic polymer particles (those having a diameter of about 0.1 to 100 µm) of nylon, PMMA (polymethyl methacrylate) and the like are incorporated into the temporarily calcined powders and the organic fibers are evaporated by normal calcination to effectively form a route through which ions pass, a voltage drop can be more reduced to a large current. In this case, the organic fibers or polymers to be used are preferably those, which are vaporized under a non-oxidizing atmosphere at high temperature. The carbon material is preferably carbonized at the calcination temperature of not less than 800°C, and preferably from 1200 to 3000°C. In this carbonization step,

thermosetting fibers are decomposed and evaporated to form communicating pores, whereas the thermosetting resin is cured and carbonized while maintaining its form. When the carbonization temperature is lower than 800°C, components other than carbon remain and those having an electric conductivity of higher than 5×10^{-3} S/cm cannot be obtained. When the carbonization temperature is not less than 1200°C, since not only hydrogen but also oxygen can be removed, a carbon mass having high electric conductivity can be obtained. A carbon thin plate can be obtained by cutting the resulting carbon mass, for example, a carbon bar into pieces having a desired thickness in the direction, which is nearly perpendicular to the formed pores. --

Please replace the paragraph beginning on page 8, line 29 to page 9, line 8, with the following rewritten paragraph:

-- The carbon thin plate may also be produced by using a substance, which is soluble in an acid, e.g. metal fibers in place of the organic fibers, curing the thermosetting resin in the same manner as that described above, cutting into pieces having a desired thickness and eluting the metal fibers with an acid. A carbon thin plate having curved communicating pores can be obtained by kneading the thermosetting resin with an inorganic salt such as sodium carbonate in place of the metal

fibers, carbonizing the mixture, followed by cutting and elution with an acid. The communicating pores may be formed by laser radiation, electron radiation, synchrotron radiation or the like. --

Please replace the paragraph beginning on page 10, line 25 to page 11, line 11, with the following rewritten paragraph:

-- Fig. 3 shows a second sandwich type cell wherein using, as a center, a composite negative electrode plate 30 obtained by forming negative electrode plates 30-1, 30-2 of the porous sintered material on both sides of a current collecting tab 20, a positive electrode plate 5-1 of the porous sintered material, an upper current collecting tab 2-1 and an upper insulating material film 1-1 are laminated on an upper negative electrode plate 30-1 through a separator 4-1, thereby to form an upper unit cell, whereas a positive electrode plate 5-2 of the porous sintered material, a lower current collecting tab 2-2 and a lower insulating material film 1-2 are laminated on a lower negative electrode plate 30-2 through a separator 4-2, thereby to form a lower unit cell. Since the cell shown Fig. 3 is the same as that shown in Fig. 1 except for the structure of the negative electrode plate, the description is omitted. Each negative electrode plate has a structure of sandwiching the current collecting tab 20 between plate materials having a

thickness which is half as large as that of the positive electrode plate. --

Please replace the paragraph beginning on page 11, line 27 to page 12, line 4, with the following rewritten paragraph:

--A lithium carbonate powder and a cobalt carbonate powder were weighed and mixed so as to be in a molar ratio (Li:Co) of 1:1, and the mixture was temporarily calcined in an atmospheric environment at 600°C for 1 hour. After grinding, acrylic fibers of a diameter of 20 µm and a length of 50 µm were mixed and the mixture was pressurized. Then, the resulting pressurized article was heat-treated in an atmospheric environment at 800°C for 10 hours and polished to obtain a positive electrode of a diameter of 15 mm, a thickness of 0.4 mm, a density of 3.0 g/cm³ and a porosity of 40. --

Please replace the paragraph beginning on page 12, line 6 to line 15, with the following rewritten paragraph:

-- A lithium carbonate powder and a cobalt carbonate powder were weighed and mixed so as to be in a molar ratio (Li:Co) of 1:1, and the mixture was temporarily calcined in an atmospheric environment at 800°C for 1 hour. After grinding, spherical PMMA particles of an average particle diameter of 5 µm were mixed and the mixture was pressurized. Then, the resulting pressurized

article was heat-treated in an atmospheric environment at 900°C for 10 hours and polished to obtain a positive electrode of a diameter of 15 mm, a thickness of 0.6 mm, a density of 3.1 g/cm³ and a porosity of 38%. --

Please replace the paragraph beginning on page 13, line 7 to line 23, with the following rewritten paragraph:

-- Production Example 4 (Production of negative electrode)

80 Parts by weight of a commercially available crystalline silicon powder (manufactured by Kojundo Kagaku Co.) having a purity of 99.9% and an average particle diameter of 1 µm and 50 parts by weight of pitch carbon (residual carbon content 50%) were mixed and dispersed in isopropyl alcohol by using a vibration mill. After the suspended slurry was allowed to stand at room temperature for 24 hours, isopropyl alcohol was removed by using a vacuum trap and a mixed powder of the silicon powder and pitch carbon was formed. The formed article had a diameter of 15 mm and a thickness of 0.4 mm. At this time, 1% by weight of polyvinyl alcohol was added as a forming aid. Forming was performed under the pressure of 1.3 ton/cm². The molded article was calcined in a nitrogen atmosphere at 1100°C at a heating rate of 100°C/hour for 3 hours, and the calcined formed article was used as the negative electrode. --

Please replace the paragraph beginning on page 16, line 20
to page 17, line 7, with the following rewritten paragraph:

-- A lithium carbonate powder and a cobalt carbonate powder were weighed and mixed so as to be in a molar ratio (Li:Co) of 1:1, and the mixture press-molded. Then, the resulting molded article was heat-treated in an atmospheric environment at 900°C for 3 hours and polished to obtain a positive electrode of a diameter of 15 mm, a thickness of 0.4 mm and a density of 2.5 g/cm³. Then, a co-condensed composition comprising 100 parts by weight of furfuryl alcohol, 46 parts by weight of 92% paraformaldehyde and 134 parts by weight of phenol was charged to fill the space a cylindrical container of an inner diameter of 18 mm in the container. After the resin is cured by placing in a dryer at 80°C for 72 hours, the resulting bar-like cured article was cut into pieces in the form of a disc of a thickness of 0.5 mm by using a diamond cutter. Then, the disc was heat-treated under an inert atmosphere at 2200°C for 3 hours to carbonize the cured resin and to decompose and vaporize the impregnated fibers, thereby obtaining a carbon thin plate of a diameter of 15 mm, a thickness of 0.4 mm and a weight of 0.07 g. This carbon thin plate was applied for the negative electrode.